

AFFTC-PA-11251



# **STATISTICALLY DEFENSIBLE TEST & EVALUATION: CURRENT APPROACHES AND FUTURE RESEARCH AT THE AFFTC**

**EILEEN BJORKMAN**

**AIR FORCE FLIGHT TEST CENTER  
EDWARDS AFB, CA**

**21 July 2011**

**A  
F  
F  
T  
C**

**Approved for public release A: distribution is unlimited.**

**AIR FORCE FLIGHT TEST CENTER  
EDWARDS AIR FORCE BASE, CALIFORNIA  
AIR FORCE MATERIEL COMMAND  
UNITED STATES AIR FORCE**

<b>REPORT DOCUMENTATION PAGE</b>				<i>Form Approved</i> <b>OMB No. 0704-0188</b>	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. <b>PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.</b>					
<b>1. REPORT DATE</b> (13-07-2011)		<b>2. REPORT TYPE</b> Technical Presentation		<b>3. DATES COVERED</b> (From - To)	
<b>4. TITLE AND SUBTITLE</b> <b>Statistically Defensible Test &amp; Evaluation: Current Approaches and Future Research at the AFFTC</b>				<b>5a. CONTRACT NUMBER</b>	
				<b>5b. GRANT NUMBER</b>	
				<b>5c. PROGRAM ELEMENT NUMBER</b>	
<b>6. AUTHOR(S)</b> <b>Eileen Bjorkman</b> <b>AFFTC/CZ</b>				<b>5d. PROJECT NUMBER</b>	
				<b>5e. TASK NUMBER</b>	
				<b>5f. WORK UNIT NUMBER</b>	
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES)</b>  AFFTC, BUILDING 1 Edwards AFB CA 93524				<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>  AFFTC-PA-11251	
<b>9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> AFFTC, BUILDING 1 Edwards AFB CA 93524				<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b>  N/A	
				<b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b>	
<b>12. DISTRIBUTION / AVAILABILITY STATEMENT</b> Approved for public release A: distribution is unlimited.					
<b>13. SUPPLEMENTARY NOTES</b> CA: Air Force Flight Test Center Edwards AFB CA                      CC: 012100					
<b>14. ABSTRACT</b> None.					
<b>15. SUBJECT TERMS</b> SDT&E					
<b>16. SECURITY CLASSIFICATION OF:</b> <b>Unclassified</b>			<b>17. LIMITATION OF ABSTRACT</b>  None	<b>18. NUMBER OF PAGES</b>  10	<b>19a. NAME OF RESPONSIBLE PERSON</b> 412 TENG/EN (Tech Pubs)
<b>a. REPORT</b> Unclassified	<b>b. ABSTRACT</b> Unclassified	<b>c. THIS PAGE</b> Unclassified			<b>19b. TELEPHONE NUMBER</b> (include area code)  661-277-8615

# Air Force Flight Test Center (AFFTC)

---

*War-Winning Capabilities ... On Time, On Cost*

## Statistically Defensible Test & Evaluation: Current Approaches and Future Research at the AFFTC



**U.S. AIR FORCE**

Eileen Bjorkman, AFFTC/CZ

21 Jul 11

(661) 275-2074

[eileen.bjorkman@edwards.af.mil](mailto:eileen.bjorkman@edwards.af.mil)

---

*Integrity - Service - Excellence*

*Approved for public release; distribution is unlimited, AFFTC-PA-No: 11251*



# Overview



- **AFFTC Mission**
- **Test Approaches**
- **AFFTC Application Examples**
- **AFFTC Way Forward**
- **Potential Research Areas**



# AFFTC Mission



- The Air Force's center of excellence for airframe propulsion, avionics and electronic warfare research developmental test & evaluation
- Leverage our location, weather, partnerships & personnel to conduct independent, objective assessments on behalf of the United States Air Force





# Test Approaches



- **Statistical**
  - **Designed Experiments**
  - **Observational Studies (may have limited scope of inference based on test design)**
- **Demonstrations**
- **SME/Opinion-Based**
- **Primary difference is in the outcome of each approach:**
  - **Validity of the result, and**
  - **Scope of inference that can be made for that test**





# AFFTC Application: Target Detection and Recognition



AFFTC



## Test Objective:

- Demonstrate the ranges at which a pilot can recognize and identify certain ground targets using imaging sensors in a targeting pod

## Test Approach:

- DOE with four factors and four response variables
- Augmented flight tests with post-flight video review

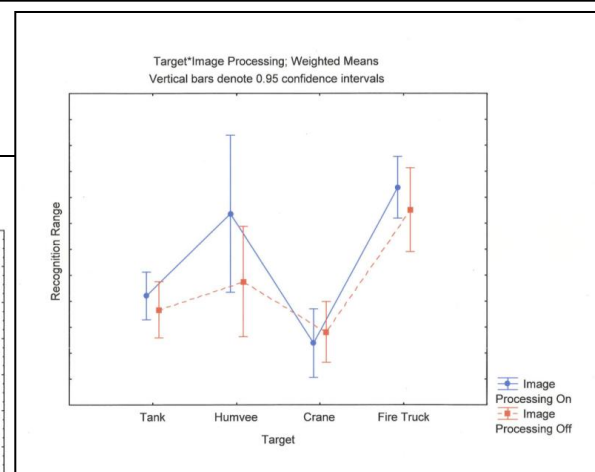
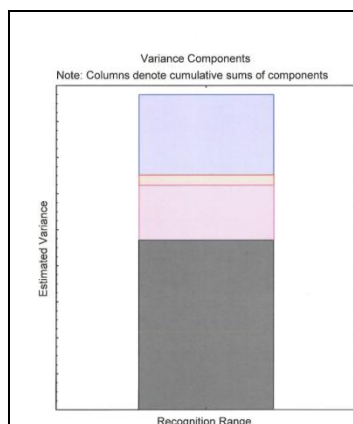
## Analysis Approach:

- Paired t-test to compare in-flight data to post-flight data
- ANOVA to determine significant factors, recognition ranges, and identification ranges

	Recognition	Identification
p-value	0.46	0.078

No statistical difference, but close!

## Results:





# AFFTC Application: Endurance Verification



## Test Objective:

- Determine if an aircraft, in mission capable configuration, has a minimum total endurance of **X** hours plus appropriate fuel reserves IAW AF instructions

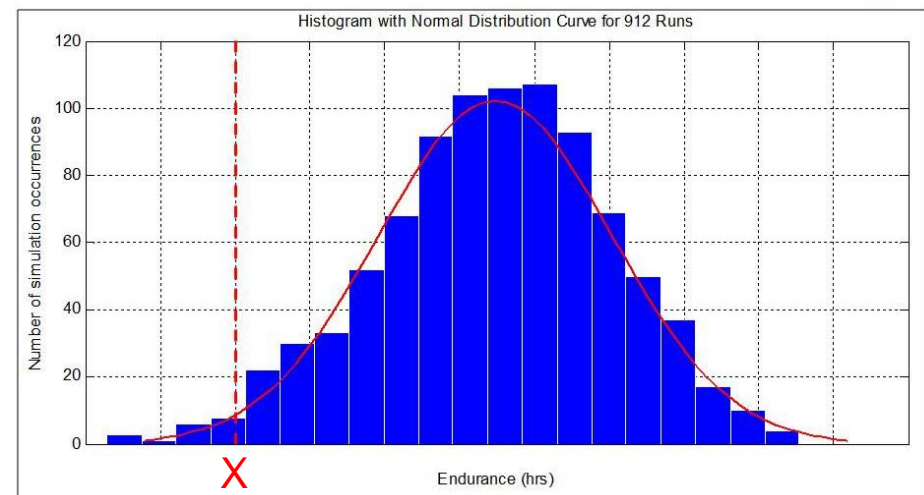
## Test Approach:

- Collect flight data regarding drag and lift coefficients, fuel flow, and static pressure error

## Analysis Approach:

- Estimate uncertainties associated with weight, outside air temperature, thrust, fuel, flow, drag coefficient, and calibrated airspeed
- Use Monte-Carlo analysis to generate expected range and endurance

## Results:







# AFFTC Way Forward



- **Developing handbook to include overview of statistics and AFFTC best practices**
- **Adding statistics input and review to our test planning and reporting processes**
- **Working potential research projects with Air Force Institute of Technology and USAF Test Pilot School**
- **Planning pathfinder projects in each flight test technical discipline**

Flight controls  
Collision avoidance  
Performance  
Human Systems Integration  
Radar Systems  
Electronic Attack

Modeling & Simulation  
Guidance, Nav, ID  
Communications  
C4ISR  
Weapons Systems  
Anechoic Facility

R&M  
Avionics  
Threat Signals  
Propulsion  
Structures  
Subsystems



# Potential Research Topics



- **Flight test techniques that take advantage of advanced computing & statistical methods**
- **Analysis of time series data**
  - Tends to be highly correlated
  - Often violates independence assumptions required for analyzing normal data
- **Quantifying aleatory and epistemic measurement uncertainties associated with:**
  - Digital data buses
  - Data models
- **Bayesian techniques**
  - Combining prior information with flight test data
  - Combining multiple models